Reamers cutting edge preparation for improvement the GGG 40 machining

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Abstract. The improvement of the microgeometry became a subject of a great interest in cutting tools optimization. This paper approaches the process of cutting edge preparation of solid carbide reamers. It has been analyzed the evolution of cutting edge wear resistance in the material GGG 40 using the scanning electron microscope (SEM). The work also compared the rounded cutting edge reamers realized using wet abrasive jet machining with standard unprepared cutting edge. To obtain different microgeometries were experienced a number of machining strategies, which resulted in four combinations of roundness and forms for the cutting edge. In order to validate the results, the author studied the wear resistance during the reaming tests, the influence of prepared surface of the cutting edge on metallic coating layer adhesion. The final purpose was to determinate the optimal strategy of cutting edge preparation considering the evolution of wear during the reaming process.

1 Introduction

The main reason for cutting edge preparation is to determinate the increase in the durability of reamers corresponding to other studies of cutting tools in this field. This aspect leads to the realization of the research regarding the microgeometry optimization of the cutting edge to increase the stability and stiffness. Improving the adhesion of metal coatings on tool surface in cutting edge area [1], and also extending the tool life in GGG-40 cast iron machining represents another benefit which motivates the effectuation of this paper. The GGG-40 (DIN 1693-1997) or EN-GJS-400-15 is the most common used cast iron around the world. The mechanical properties could be compared with cast steel because the tensile strength, ductility and toughness are much better than grey cast iron. This type of material could be used to produce impact-resistant and shock-resistant parts, such as the wheel hubs in automotive, drive axle housing, differential carrier, motor boxes and more [2].

Reamers are an important part of the cutting tools and very used worldwide, specific in the metal machining industry for the processing of the hole, which has the precise diameter, roundness and roughness of surface in asked tolerance. To realize the tests were used carbide monobloc reamers Ø8H7 with six cutting edge unequal divided, right flutes and axial cooling from Gühring.

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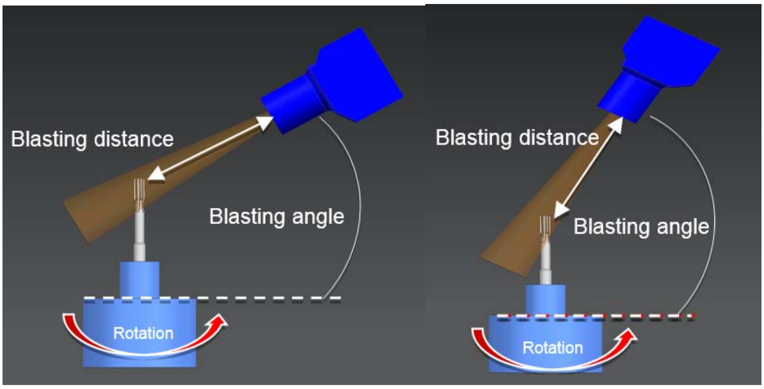
It is widely known that by increasing the size of cutting edge rounding results in a higher edge stability. The most usual preparation methods are dry and wet abrasive jet machining, brushing and drag finishing. Further investigated methods are brush polishing, magneto abrasive machining, abrasive flow machining, laser machining and grinding approaches [1]. Research has proven that the cutting edge microgeometry increases the tool life and machining quality in comparison with the reference tool with the sharp edge [1,3,4]. The maximal durability can only be achieved through a combination of tool coating and adapted cutting edge microgeometry [5]. For this test the reamers were coated with the new Signum coating developed by Gühring, which is one of the hardest nitride coatings on the market.

2 Cutting edge preparation

The microgeometry refers to the radius or faze of cutting edge and the edge symmetry define by the K-Factor obtained after its preparation. According to Denkena [1] the microgeometry is a very important element in the evolution of wear and gives higher edge stability due to the fact that it reduces the mechanical stress concentration.

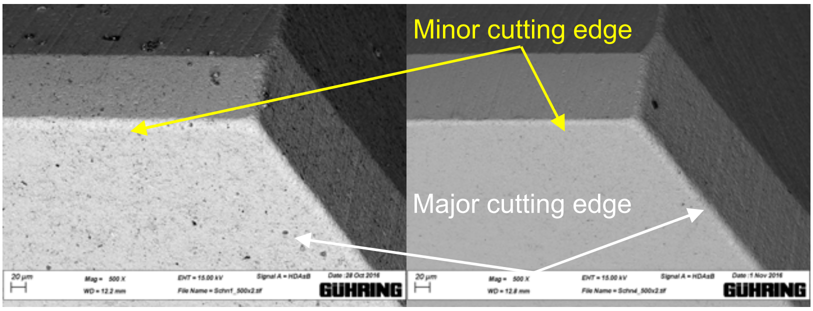
In order to determinate the optimal cutting edge microgeometry for this type of reamers, two different cutting edge roundings were prepared through wet blasting with two different kinds of strategies for each radius value. The other important blasting parameters that can be set are pressure of the compressed air, time of process, distance and angle between nozzle and tool, and the rotation speed of tool under the jet blasting medium. The difference between the strategies is the blasting angle, which was 30° between the nozzle and the horizontal axis for the first one and at the second strategy, the angle of the nozzle inclination was at 60°. During the process, the tool was in a continuous rotation to obtain the equal radius on each cutting edge (Figure 1).



a) Strategy 1 with blasting angle 30° b) Strategy 2 with blasting angle 60°

Fig. 1. Process of preparing the cutting edge.

The purpose of the first strategy was to obtain equal rounding of the major and minor cutting edges of the cutting tool. This was possible by acting equally at the rake and flank face. The deviations from the desired value of rounding in this case were between ± 5-10%. For the second Strategy with a 60° blasting angle, it results in a larger rounding on the major cutting edge, about 30-40% more than on a minor cutting edge. In addition, the deviation from the required rounding increases in the range of ± 13-20%. (Figure 2)



a) Cutting edge after Strategy 1 b) Cutting edge after Strategy 2

Fig. 2. Reamers cutting edge after wet blasting.

In the present research were chosen the round form edge microgeometry for the cutting edge with a K-Factor equal with 1. The values of the prepared cutting edge rounding were 10 and 15 µm and they were chosen after studying appropriate scientific literature. It is known that a higher radius can increase process forces and the thermal loads on the edge. This can be attributed to the increased friction component on the flank face and increased plastic deformation in the secondary shear zone [6].

2.1 Cutting edge measurement

The repeatability of obtaining microgeometries established as optimal is mandatory in the series production of cutting tools. The Edge Master Module from Alicona was used to measure microgeometry after the cutting edge preparation to ensure that this criterion was applied for all reamers and also for each cutting edge. The cutting edge radius r_{β} is determinate by a constant circle that is fitted into the intersection of the flank face and the rake face (Figure 3).

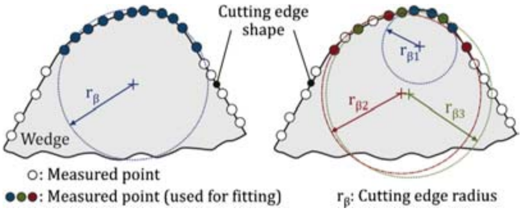


Fig. 3. The radius describing cutting edge geometry [6].

3 Tool life test

The reamers durability tests were done with the next cutting parameters V_c= 250 m/min, f_u= 0.4mm/rot and cutting depth of the hole a_p=30 mm, with a predrilled hole of 7.8 mm in diameter. The experiments were made on a three axis vertical CNC milling center in laboratory conditions. Also the roughness of hole surface (Ra and Rz) was measured, which along with the dimensional criterion and the worn cutting edge represents an important criterion to stop the durability test. The upper roughness tolerance was Ra=1.2 µm and Rz=8 µm. Regarding previous criteria the results of durability tests showed that the all reamers with cutting edge preparation have a considering increase between 40-50% of tool life in comparison with the reference standard reamers (Figure 4).

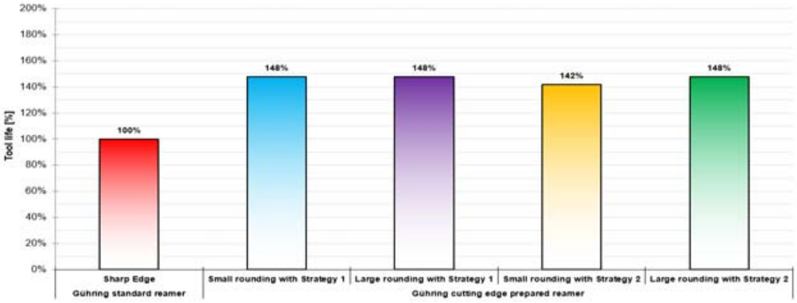
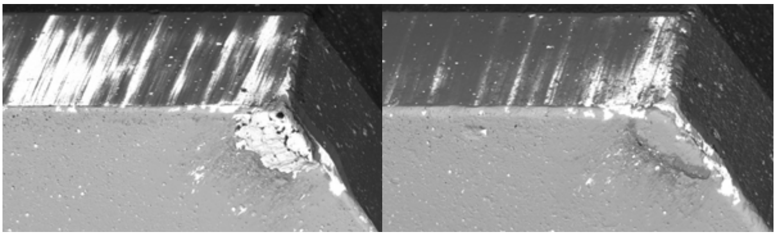


Fig. 4. Results of the durability test.

To identify which combination between the micro rounding and the wet blasting strategy work well, was necessary to analyse the wear of the cutting edge. This analysis was realised using the SEM microscope for each cutting edge, then the most worn edge from each reamer was chosen and then a comparison between them was done (Figure 5). In this case the diagram from Figure 4 indicates that strategy 1 have the best results for both rounding edge values, thus remains only to decide which prepared rounding leads to the less wear for the cutting edge.



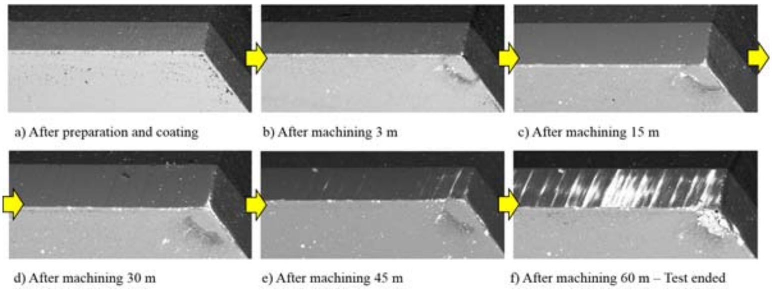
a) Strategy 1 with 10 µm rounding b) Strategy 1 with 15 µm rounding

Fig. 5. The comparison between the most worn edges from first Strategy.

It can be seen that the reamers with a larger micro rounding developed a lighter wear comparing to the reamers with small micro rounding and have a better durability for the both strategies.

4 Discussions about wear form and evolution

During the research, the tools were analyzed at predefined intervals of: 3, 15, 30, 45 and 60m to study the cutting edge wear and deterioration. At these intervals, the wear of the cutting edge was scanned using an electron microscope to observe the evolution of the wear, material adhesion and coating deterioration.



a) After preparation and coating
b) After machining 3 m
c) After machining 15 m
d) After machining 30 m
e) After machining 45 m
f) After machining 60 m – Test ended

Fig. 6. Wear evolution during the durability tests.

Based on the images of the wear evolution from Figure 6 it can be observed that the abrasion tendencies of major cutting edge at the intersection with minor cutting edges.

The maximal contact area between the tool and the cutting material and where the wear begins can be seen after 3 m of machining but in general at this point it is considered negligible.

During drilling processes compared to reaming, a light wear of the cutting edge can be distinguished at the first few holes.

The evolution of wear studied at SEM microscope is not significant in this research with prepared cutting edge of reamers, until 45 m of material are machined. After this limit, the coating from circular land width and around the edge is starting to wear off.

On the uncovered carbide especially at the edges material adhesion appears, which can increase the roughness of cutting holes surfaces, which determines the ending of the test.

On the circular land width at the last picture (Figure 6), the longitudinal feed traces can easily be seen. They are caused by the extremely unequal spacing between the cutting edges. It is possible that the hardened material remained after the previous edge, can scratch the reamer coating and so appears this effect.

After a few more holes the reamer diameter begins to reduce and the cutting hole exceeds the allowed tolerance. Sometimes a fake cutting edge takes shape and the hole diameter returns in tolerance but only for a short period.

5 Conclusions

It can be concluded that the cutting edge preparation with a micro rounding in the range of 15 μm increases the reamers tool life in GGG 40 machining and works better for both strategies. The advantages of this preparation include also the repeatability of the process and the possibility to be introduced in the manufacturing tools cycle on an industrial scale.

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